A VEGETATIONAL SURVEY OF THE VASCULAR PLANTS OF THE KENT ISLAND GROUP, GRAND MANAN, NEW BRUNSWICK[1]

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In 1930, Mr. J. Sterling Rockefeller, interested in preserving the eider ducks that breed along the coast of the northeastern United States, purchased Kent Island, on which the eiders nest. In 1934, he gave the island to Bowdoin College as a breeding bird preserve and field study station. Extensive ornithological work has been done at this station over the years, but there have been only limited botanical investigations. Dr. David Potter (1936, 1937) and John McCain (1973) compiled vascular species lists, and Henry A. Gleason, Jr. (1937) sampled herbaceous vegetation in the forested northern end of Kent Island. The present study was designed to survey and map the vegetation of the entire island and to define the plant community types in the non-forested areas. It is also intended to serve as a reference for future ornithological research on Kent Island.

Kent Island lies at 66°46′ E longitude and 44°35′ N latitude, about fifteen miles east of the coast of Maine in the Bay of Fundy. It is the outermost island in the Grand Manan Archipelago and is politically part of Charlotte County, New Brunswick, Canada. Its greatest length is 1.75 miles and its width varies from one-ninth to one-half mile. The title deed lists the area at 150 acres.

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All of Kent Island is now covered with water-worked glacial till (Meserve, 1937). The only major relief is an upland area with twenty-foot sand cliffs on the northern end of the island and two fifty-foot hills at the far southern end. The northern and western ends are heavily wooded, and the west end is low and marshy. A 7.8 acre tidal basin on Kent Island is flooded twice daily by tides averaging 14.4 feet. Kent is the largest of what local fishermen call the Three Islands. Fifty acre Hay Island is forested except for one large field on the south shore where a few now uninhabited houses and a weathered barn still stand. It can be reached on foot from Kent Island at low tide. Thirty acre Sheep Island is a low flat island with vegetation resembling the south end of Kent Island. It has no woody plants.

MATERIALS AND METHODS

I was able to spend six weeks during the summer of 1968 and ten weeks during the summer of 1969 on Kent Island at the Bowdoin Science Station. In 1968, a general survey of the plant cover of the entire Three Islands group was made, and quantitative sampling of the vascular flora of the forests was completed. Aerial photographs taken in 1965 were used to supplement the field studies in mapping the vegetation of the islands (Fig. 1). To determine the relative frequency of the forest herbs, a 100-foot grid was established in the wooded areas of Kent Island using a Brunton compass, and meter quadrats were set up at the intersections and at the 50-foot marks.

The non-forested areas, identified in the 1968 survey, were sampled in 1969 by the line-intercept method. A non-forested area, as defined for the purposes of this study, is one in which herbs or shrubs are the dominant species and where trees, if present, do not form a closed canopy. Eleven such areas were defined. In each area, either a two- or a five-hundred foot transect was established along a compass line. Absolute and relative dominance, and relative density were calculated for plant species intercepted, according to the

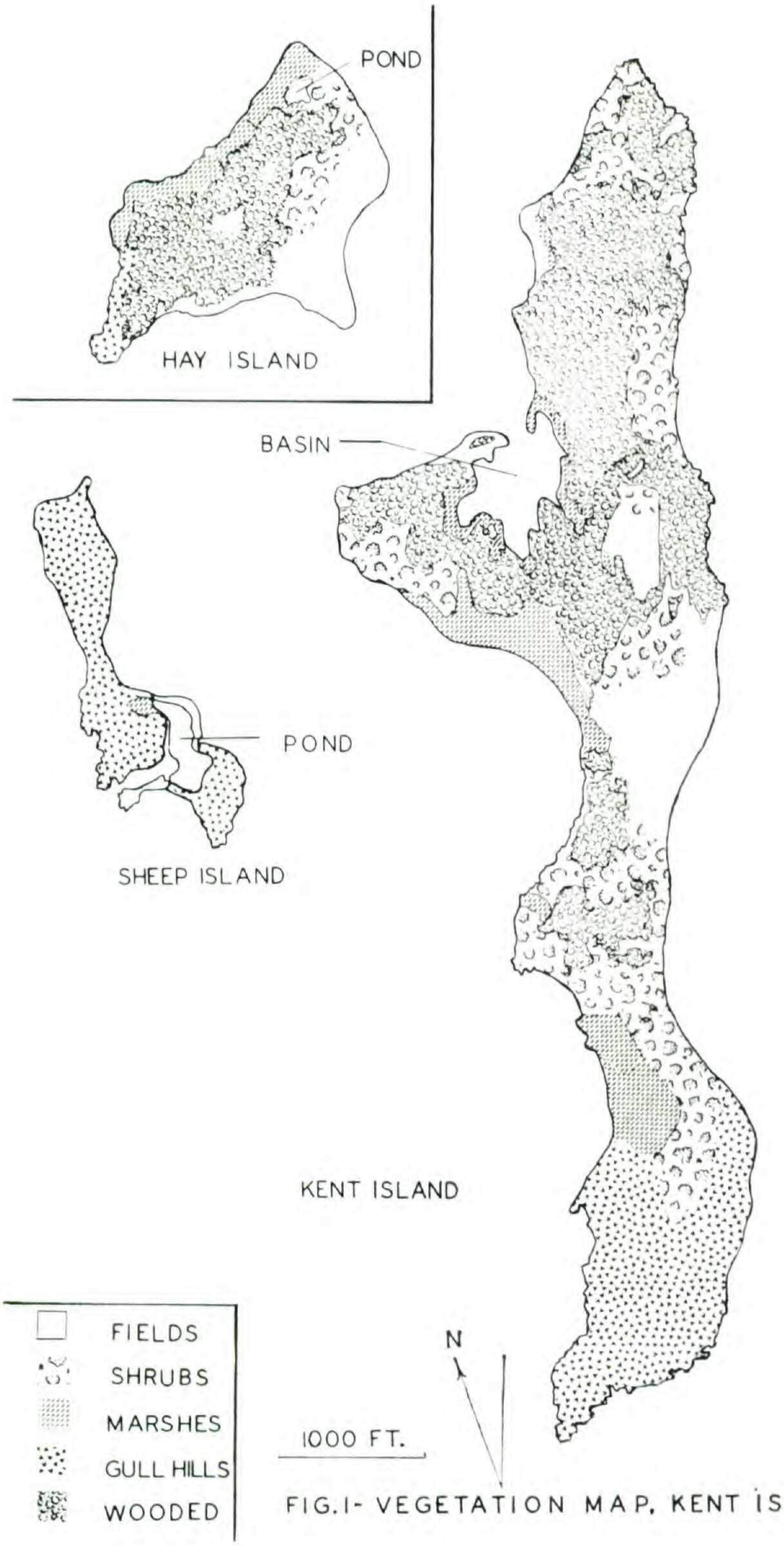

FIG. 1- VEGETATION MAP, KENT IS.

method of Cottam and Curtis (1962). Absolute dominance is expressed in this paper as "% cover", a measure of the number of herbs or shrubs of a given species intercepting each segment of the transect line. Since several different species may overlap one another, the total "% cover" will often exceed 100%. Relative frequency was determined through the use of nested quadrats offset by a random numbers table at twenty-five foot intervals along the transect line. The sum of relative frequency, relative density, and relative dominance (of woody species) is the Importance Value (IV) of a species on a given transect. The sum of all species' Importance Values on each transect should equal 300 for shrubs, 200 for herbs.

Soil samples were taken from the A_1 layer at each sixty-five foot mark, and used to determine soil moisture and water retaining capacity (WRC) by the Hilgard-cup method, and pH by the use of pHydrion paper. In soils with high organic content, the WRC values often exceed the dry weight of the soil itself.

Seymour (1969) was used for the identification of the plant specimens with the exceptions of the two groups indicated in the previous paper on the Kent Island flora (McCain, Pike & Hodgdon, 1973).

RESULTS

Collections totaling 240 species and 10 varieties of vascular plants were made on the Three Islands in 1935 by Dr. David Potter of Clark University, in 1968-69 by the present author, and in 1970 by Dr. A. R. Hodgdon and R. B. Pike of the University of New Hampshire. These collections were listed in McCain *et al.* (1973). Ninety-four of the genera in the total list (66.2%) are represented by one species only, as are twenty-one of the families (39%). Of the fifty-four families, six (Gramineae, Cyperaceae, Polygonaceae, Caryophyllaceae, Rosaceae, and Compositae) account for 48% of the species present on the island, and for 100% of the species intercepted in the nesting areas of the islands' sizable herring gull population. The presence of these birds may be the main cause of the lack of floristic diversity.

Eighty-five one-meter quadrats sampled in the forested areas showed a ground layer homogeneous in species composition but widely varying in density of individuals. In the more open areas, or along the forest edge, *Dryopteris spinulosa* var. *americana* was clearly dominant and the total higher plant cover averaged 88.13% under spruce-fir and 70.56% under mountain ash and canoe birch (*Betula papyrifera* var. *cordifolia*). Where the spruce are 20-30 feet tall, they form a very dense thicket. Here the higher plant cover averaged only 32.86%, with *Oxalis montana* and *Maianthemum canadense* dominant. In several of the denser spruce thickets, higher plant cover was entirely absent in the herb layer. The understory there suffered not only from a lack of light but also from a shortage of soil moisture. Most rain is intercepted by the dense canopy and most of the throughfall is caught by the deep litter layers before it can penetrate to the soil itself where it would be available for the understory plants. Mean higher plant cover in all eighty-five quadrats was 55.17%. Lower plant cover averaged 31.43% in the dense areas, 10.89% under the open stands.

The most important herb species in the wooded areas was *Aster acuminatus* (%F = 60.0). *Rubus idaeus* var. *canadensis* was the most common woody species, occurring in 28.2% of the quadrats. In openings or blowdowns, it often accounted for nearly 100% of the cover. Table 1 shows the relative frequency values for the forest floor species. Gleason (1937) sampled one hundred similar plots on Kent and Hay Islands, finding corresponding values for the species present. The major exception was that *Oxalis montana* was the most abundant species in his study, occurring in 44% of his quadrats. In 1968, *O. montana* was present in 24.7% of the quadrats in the total sample, but was present in 71% of the quadrats in denser areas where the spruce was roughly 25-40 years old. This change in the presence of *O. montana* suggests a change in the age structure of the tree population, with the sorrel giving way to larger species, often *Dryopteris* or the mountain aster, in the older, less dense woods.

Table 1. Kent Island species occurring in more than 5% of forest area quadrats sampled, 1968.

Species	% frequency
Shrubs	
Rubus idaeus L. var. *canadensis* Richardson	28.2
Herbs	
Aster acuminatus Michx.	60.0
Dryopteris spinulosa (O. F. Mueller) Watt. var. *americana* (Fischer) Fern.	38.8
Rumex acetosella L.	38.8
Oxalis montana Raf.	24.7
Trientalis borealis Raf.	21.1
Maianthemum canadense Desf.	16.4
Cornus canadensis L.	10.2
Poa pratensis L.	9.4
Circaea alpina L.	9.4
Impatiens capensis Meerb. forma *immaculata* (Weath.) Fern. & Schub.	8.3
Stellaria media (L.) Cyrillo	8.2
Anthoxanthum odoratum L.	7.1
Carex brunnescens (Pers.) Poiret var. *sphaerostachya* (Tuck.) Kukenthal	5.9
Streptopus amplexifolius (L.) DC. var. *americanus* Schultes	5.9

Four groups of non-forested stands can be clearly defined. The first includes the old fields near the middle of Kent Island and the main field on Hay Island. All are composed of turf grasses like *Agrostis stolonifera* and *Festuca rubra* and perennial composites such as *Solidago rugosa* var. *villosa*. These fields are relatively sheltered both from the salt spray and the weather but show the greatest influence of man both in terms of cutting and of introduced species. Most of these areas were cleared for planting of forage crops, notably *Phleum pratense,* in the nineteenth and early twentieth centuries. Shrub cover is uniformly low: 1.0, 14.40, 16.60, and 16.71% on the transects studied. Herb cover is the highest of the four groups, with an average in these fields of 386.37%. The old field transects all included a greater number of plant species than any of the other transects studied.

The second group consists of raspberry and shrub communities. *Epilobium angustifolium* is found in association with *Rubus idaeus* var. *canadensis* in blowdowns and open areas along the north and east shores of Kent Island. Shrub cover values are uniformly high with a mean of 103.96%, but herb cover dropped to 180.37%. Each of these areas is the site of active gull nesting, and, as a result, has a very rich soil with a high organic content.

Fresh-water and salt marsh communities along the western shore of Kent Island and on the north shore of Hay Island are in the third group. *Iris versicolor* (Importance Value = 19.46), *Carex canescens* var. *disjuncta* (IV = 23.18) and *Epilobium glandulosum* var. *adenocaulon* (IV = 20.65) are the most important species of these areas. Shrubs, but for *Ribes lacustre,* are seriously limited, except where the marsh is the last remnant of an old raised bog. In those places, *Kalmia angustifolia* and *Ledum groenlandicum* are the dominants, growing over *Sphagnum* moss. Only one small part of a formerly very extensive bog is left on Kent Island because of the maturing of the forests and man-made changes in the drainage patterns. There is one heath remnant, perhaps twenty feet in diameter, at the north edge of the bog area, the sole location found for five species of the flora: *Calopogon tuberosus, Arethusa bulbosa, Sarracenia purpurea, Rubus chamaemorus* and *Empetrum nigrum.*

In the fourth group, the South Hills of Kent Island and all of Sheep Island, are the main nesting areas of the islands' estimated 23,000 breeding pairs of herring gulls.

This very disturbed area supports dense populations of several plant species found only infrequently elsewhere on the island, and then only as weeds. For example, common ragweed (*Ambrosia artemisiifolia*) normally loses out in competition to the grasses and other composites. On the South Hill, however, *Ambrosia* has an importance value of 58.02, second only to *Aster foliaceus* var. *arcuans* (IV = 64.62). *Rumex acetosella*, another weed, is similarly favored by these disturbed conditions (IV = 14.28). The number of species found on the South Hill is also undoubtedly held down by the gulls. Only eight herb species and one shrub (*Rubus idaeus* var. *canadensis*) appeared on the 500 feet of South Hill transects. By comparison, the four old field transects averaged 26 herb species and 3 shrub species.

Clearly the most frequent herbaceous species of the non-forest areas is the ubiquitous blue aster *A. foliaceus* var. *arcuans*. On all four field transects, on the north shore of Hay Island, and on the gull hills at the south end of Kent Island, it is the species with the highest importance value. *Aster foliaceus* was present in some degree in all eleven of the transect samples.

The most frequent shrub species, in both forested and non-forest areas, is *Rubus idaeus* var. *canadensis*. Raspberry plants covered over half of the line on the four shrub community transects: the south field (%cover = 92), North Clearing (86.5%) Downer's Field (51%), and the Crockett's Point Field (69%). No other shrub was so clearly dominant in any of the areas sampled. *Ribes lacustre* was a dominant shrub (18% cover) in the Hay Island north shore marshes, but, where *Ribes* and *Rubus* are both present, the red raspberry is clearly more dominant than the currant.

Soil moisture values vary from 19.5% in the North Field to 69.0% on the South Hill (Table 2). The South Hill also varies significantly in mean pH values from the rest of the island. The other groups of stands have mean pH values of 5.67, 5.77 and 5.60, while that of the South Hill is only

4.93. WRC values are consistent within each of the four groups, except for a high of 629.90% on Crockett's Point where much poorly decomposed *Sphagnum* moss appeared in the soil profile. Soil data is summarized in Table 2. The extreme values for soil moisture and pH in the South Hill are certainly factors in the presence of a vegetation typical of disturbed areas. However, careful study may show that the mechanical destruction of plants due to the perching, pulling and pecking of the gulls may be more harmful to plant survival than the chemical alteration of the soil caused by their droppings.

Table 2. Soil analysis data.

Stand	Transect	% Soil Moisture	pH	WRC (%)
North Field	I.	19.5	6.05	121.18
Hay Field	II.	26.2	5.58	148.50
West Field	III.	29.8	5.40	82.96
East Field	IV.	34.4	5.38	61.95
North Clearing	V.	28.0	5.80	105.55
South Field	VI.	34.7	5.70	22.64
Downer's Field	VII.	39.5	5.80	29.42
Crockett's Point	VIII.	41.0	5.80	629.90
West shore	IX.	40.0	5.70	425.44
Hay north shore marsh	X.	40.2	5.50	300.00
South Hill	XI.	69.0	4.93	196.53

Mean Values

Transect Group	% Soil Moisture	pH	WRC (%)
I-IV (Old fields)	27.48	5.67	103.50
V-VIII (Shrubs)	35.80	5.77	*52.54
IX-X. (Marshes)	40.10	5.60	362.72
XI. (South Hill)	69.00	4.93	196.53

*discounting high value for transect VIII.

The remaining botanical area of the islands is a zone just above the highest tide lines, favored mostly by halophytes, the most important among them apparently being *Cakile edentula, Atriplex patula* var. *hastata* and *A. glabriuscula, Lathyrus japonicus* var. *pellitus, Mertensia maritima,* and *Arenaria peploides* var. *robusta.* There are also a few perennials mixed in at the upper edge of this zone, notably *Aster foliaceus* and *Urtica procera.* A few plants have ventured out onto the floor of the tidal basin where they are covered twice daily by the waters of high tide: *Salicornia europaea, Glaux maritima, Limonium nashii, Suaeda maritima* and *S. americana.* Prominent growths of *Spartina alterniflora* and *Hordeum jubatum* line the edge of the basin. No statistical sampling has yet been done in these zones.

DISCUSSION

Three characteristics of the flora are especially worth noting. The first is the paucity of species. About one-half of the genera (56.44%) and one-fourth of the families (27.37%) in mainland New Brunswick are represented by a single species (Fowler, 1885). On Kent Island, two-thirds of the genera and two-fifths of the families are monotypic. The recentness of colonization could be a factor in the lack of diversity of flora, for all of the Grand Manan Island group was covered during the last glaciation. Thus there has been little time for proliferation of immigrants. The second possible factor is the presence of the herring gull colony. In work on three similar islands nearby in the Bay of Fundy, Hodgdon and Pike (1969) concluded that "the screening effect of bird populations is more apparent than their transport of propagules". This seemed to be true on Kent Island where the gulls probably prohibit by their activities the establishment of many potential immigrants and of many woody species. The continual disturbance caused by the birds maintains the area in early stages of succession. The abundance of a group of fast growing, sun loving species typical of pioneer habitats, including *Achillea millefolium*, *Rumex domesticus* and *R. acetosella*, *Urtica procera*, *Coelopleurum lucidum* and *Ambrosia artimisiifolia*, indicated that these plants apparently benefited from the gulls' presence.

The second notable characteristic of the flora is the presence of a high number of boreal species for this latitude. Nearly three-fourths of the Kent Island species have ranges that extend north and west from this area. Such species as *Rubus chamaemorus*, *Empetrum nigrum*, *Vaccinium vitis-idaea*, *Stellaria humifusa*, and *Euphrasia americana* reach their extreme southeastern limits in the Kent Island region. The reason for their presence here is the cool, damp climate of the Bay of Fundy. The warm Gulf Stream and the cold Labrador Current meet near the mouth of the Bay. During the summer the prevailing wind is from the south or southwest over 50% of the time. Thus the air is considerably warmer than the waters of the Labrador Current and of the Bay of Fundy (which seldom exceeds 50°F. even in midsummer) and the result is very frequent dense fog.

In the ten-day period beginning 26 July 1969, for example, the greatest visibility was just under one mile and the mean daily low visibility was about one hundred feet. The fog-drip caused by the condensation of this heavy fog on tree limbs increases the humidity at the herb level.

Table 4 shows pertinent weather data for the years 1965-69. Year-round weather records for the five-year period 1937-1941 may be found in Cunningham's report (1942).

The third important characteristic of the flora is that many of the new species reported in 1968-69 are weeds evidently introduced by man, probably after the previous studies were done in 1936. Thirty-one of these sixty-one new species were found in the field where the houses are on Hay Island, and on Kent Island near the wharf, along the main path, or in the area of the dormitory in the central part of the island. Conspicuous among these species are *Trifolium pratense*, *Convolvulus sepium*, *Chenopodium* *album, Galeopsis tetrahit, Chrysanthemum leucanthemum*, and *Hieracium aurantiacum*. These species are often spread by man, and are too conspicuous to have been missed by Potter in his work.

Nearly all of Kent Island was once wooded and has been cut over at one time or another (Gleason, 1937). The northern and western ends are now wooded, with white spruce (*Picea glauca*) dominant in successional areas where the forest is encroaching on the fields and in blowdown areas. Balsam fir (*Abies balsamea*) is reproducing better in the more established woods.

Table 3. Herbaceous and woody species cover.

Stand	Transect	Shrub cover (%)	Herb cover (%)
North Field	I.	16.71	421.56
Hay Field	II.	1.00	489.50
West Field	III.	16.60	317.40
East Field	IV.	14.40	317.00
North Clearing	V.	86.50	212.50
South Field	VI.	184.00	93.00
Downer's Field	VII.	69.00	203.00
Crockett's Point Field	VIII.	76.33	212.97
West shore marsh	IX.	10.00	389.00
Hay north shore marsh	X.	7.50	156.00
South Hill	XI.	16.80	175.40
Mean Values			
Transect group			
I-IV (Old fields)		12.18	386.37
V-VIII (Shrubs)		103.96	180.37
IX-X (Marshes)		8.75	272.50
XI. (South Hill)		16.80	175.40

Table 4. Meteorological summary of Kent Island, New Brunswick, Canada, 1965-1969. (Bowdoin Science Station Weather Records)

Month	Avg. Mean Max. T.°F.	Avg. Mean Min. T.°F.	Avg. Total Prec., in.	Avg. Days Fog/Month
June	57.2	44.6	2.49	13.0
July	61.8	48.8	2.44	17.8
August	62.3	50.5	3.08	15.6

Avg. total days with fog for the three month period: 46.4.
Mean annual precipitation (Cunningham, 1942): 44.86″.

The four classes of non-forested areas vary in terms of soil water and plant cover. Table 2 lists soil moisture content, water retaining capacity, and pH by transects and Table 3 lists woody and herbaceous species cover by transect. In the old fields, the driest areas studied, the herbaceous species seemed to be encouraged. As the moisture content of the soil increased, the shrubs increased, but the total water the site could hold decreased as did the number of herbs. In the marshes the water content became high enough to inhibit the number of shrubs, and another group of herbaceous species took over.

Finally, the highly organic soil of the South Hill had a high moisture content, but a lowered WRC. This is surprising since water retaining capacity usually increases with increased soil organic content. The increased acidity of these areas may have limited both the herbs and shrubs in variety. Where the gulls nest in areas with trees, they are destroying the woody plants. The south hills of Kent Island were formerly forested, as is evidenced by many fragments of decaying wood found in the soil, but the constant influence of the gulls has left only an area of twisted and broken snags where *Rubus idaeus* has now taken over. Many trees have been killed by the severe mechanical damage caused by the gulls. Some others have become stunted and have formed an unnaturally dense and tangled crown, thick enough and strong enough to support a man.

In some of the most heavily disturbed areas, the grass pulling of the gulls keeps large areas of ground completely barren of all vegetation. The largest such barren area in 1969 measured nearly fifty feet by thirty feet. The vegetation around these barren areas is almost purely *Ambrosia artemisiifolia*. This weedy species emphatically underlines the extreme disturbance by the gulls of this part of the island. Nowhere else in the Three Islands group are conditions nearly so favorable for this species.

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